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DUQUESNE SCIENCE COUNSELOR

for better science teaching

A QUARTERLY JOURNAL OF METHODS AND INFORMATION FOR TEACHERS OF SCIENCE

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DUQUESNE SCIENCE COUNSELOR

FOR BETTER SCIENCE TRAINING

Volume XXIV DECEMBER, 1961 No. 4

CONTENTS

PRESENT—FUTURE ISSUES

Teachers like to believe that they exert some influence in the lives of their students. To test this belief, THE DUQUESNE SCIENCE COUNSELOR asked a number of eminent scientists whose contributions are of great interest to both the professional educator and the lay public. Continuing in this issue is the second installment, a statement by the former Nobel Prize winner, Dr. George W. Beadle. Look for the contribution of the "Father of the H-bomb" in the next issue.

M.A.S.

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The world famous geneticist and former Nobel Prize winner, Dr. George W. Beadle, has kindly responded to the Duquesne Science Counselor's invitation to comment on the science teacher who influenced him most during his life. Below is Dr. Beadle's Statement.

The Science Teacher and His Students

Because my career in science was the result of the influence of a high school teacher, I am glad to reply to your request, if only as a small recognition of my debt. The teacher was Miss Bess McDonald (now Mrs. J. C. Higgins) who taught physics and chemistry in Wahoo, Nebraska, High School. She taught good courses; in fact, her chemistry course enabled me to coast through my first college course at Nebraska College of Agriculture. Her own knowledge of chemistry and physics was gained from general college courses in those two subjects and she made no pretense of being an authority. But she was interested in her pupils and excited about teaching science. She encouraged curiosity, and had many of us putting in extra time after school on experiments which she suggested or let us work out for ourselves. She was always ready to discuss problems of the course and I spent many evenings at her family's home with her. When she didn't know something she freely admitted she didn't, but sent us off to find out from books. As well as encouraging my interest in science, she urged me to go to college, which hadn't been planned. My father expected me to run the farm after I graduated from high school, but when Miss McDonald's urging crystallized my vague interest, he let me do as I wanted. The interest in science which I took with me to college was never lost, and again, because of particularly fortunate association there with another teacher, Franklin D. Kiem, my interest was strengthened. It all started because Miss McDonald created in me the excitement of learning to ask and to find the answers.

George Beadle

Dr. George W. Beadle, Biologist, was born in Wahoo, Nebraska, October 22, 1903 and received his Ph.D. from Cornell University in 1931. He was a National Research Council fellow at California Institute of Technology 1931–1933 and instructor 1933–1935 and guest investigator at the Institute of Biology, physics, chimique in Paris, 1935. From 1936–1937 he was assistant professor of biology in the field of genetics at Harvard University and from 1937 to 1946 he was professor at Stanford University. Since then he has been professor of biology and the chemical division of biology at California Institute of Technology and just recently has been elected Chancellor of the University of Chicago.

The following article is adapted from a paper presented at the Spring Meeting, 1961, of the Pennsylvania Catholic Round Table of Science meeting held in Scranton, Pa.

Giving Mathematics Meaning

BY JOAN MONTGOMERY

Villanova University, Villanova, Pa.

Many of you, in fact most of you, are probably familiar with the new methods of teaching. Perhaps though, some of you have not had the opportunity to see for yourself how this new approach works in the classroom.

The fact that working by discovery, finding patterns, and recreating mathematics delights children is true, at least it has been so in my experience.

I teach at a large junior high. My classes include the top two rosters in seventh grade and the eleventh and twelfth groups out of a total of eighteen rosters. In other words, I teach the academically talented students and two average groups.

Today I want to show you in part some of the things my best groups have done in conjunction with the Maryland Plan (see editor's note) which we use. The influence on the other groups will also be apparant to you.

In the beginning of the year after studying about different base notations (including base 2, base 5, base 12, and our own base 10) we move along to a study of factoring and primes. In this section we try to prove that an even natural number plus an even natural number is always even, an even times an odd is always even, an odd times an odd is always odd, etc. We made up our own notation for this and proved all of the following, (**E** represents an even number and **O** represents an odd one.)

$$\mathbf{E} + \mathbf{E} = \mathbf{E} \qquad \mathbf{E}\cdot\mathbf{O} = \mathbf{E}$$
$$\mathbf{E} + \mathbf{O} = \mathbf{O} \qquad \mathbf{O} + \mathbf{O} = \mathbf{E}$$
$$\mathbf{E}\cdot\mathbf{E} = \mathbf{E} \qquad \mathbf{O}\cdot\mathbf{O} = \mathbf{O}$$

The students had finished a discussion of the closure, commutative, associative, and distributive properties of natural numbers, under various operations. Using this knowledge and the fact that an even number must have a factor of 2 we were able to prove the six above mentioned facts by representing an even number as $2\cdot a$ and an odd one as $2\cdot b + 1$ where a and b represent natural numbers. I shall use $\mathbf{O}\cdot\mathbf{O}$ to illustrate. We want to get something that looks like $2\cdot c + 1$ to prove our answer is odd. This proof shows that all odd $\times$ odd problems give odd for an answer.

$(2\cdot a + 1)\cdot(2\cdot b + 1)$ statement of problem
$(2\cdot a + 1)\cdot 2\cdot b + (2\cdot a + 1)\cdot 1$ distribution
$2\cdot a\cdot 2\cdot b + 2\cdot b + 2\cdot a + 1$ distribution
$(2\cdot a\cdot 2b + 2\cdot b + 2\cdot a) + 1$ association
$2[(a\cdot 2\cdot b) + b + a] + 1$ distribution
$2\cdot c + 1$ closure

When we finish these proofs we branch out into telling if a number is odd or even. In base 10 this is easy. We need simply to look at the last digit to tell. 106823 is odd. 248116 is even. But in other bases this is not always the case. Take base 3 as an example.

$$12_{(3)} = 1\cdot 3 + 2\cdot 1 = 3 + 2 = 5_{(10)} \text{ or odd}$$
$$21_{(3)} = 2\cdot 3 + 1\cdot 1 = 6 + 1 = 7_{(10)} \text{ or odd}$$

Notice that in these examples the number was odd with an even last digit and an odd last digit. Take $11_{(3)} = 1\cdot 3 + 1\cdot 1 = 4$ or an even number. We wanted a scheme for telling quickly without expanding our numerals if the number was odd or even.

I gave this as an extra credit assignment. I have one boy's work just as he gave it to me. I would like to read it to you to see what you think of his reasoning.

PROOF THAT IF YOU ADD THE DIGITS OF AN ODD BASE YOU CAN TELL IF THE NUMBER IS ODD OR EVEN

For an example: $43265_{(7)} = 4\cdot 7^4 + 3\cdot 7^3 + 2\cdot 7^2 + 6\cdot 7^1 + 5\cdot 7^0 = 9604 + 1029 + 98 + 42 + 5 = 10778_{(10)}$

This is an even number. Adding the digits of $43265_{(7)}$ you get an even number 20.

Let's take the number digit by digit. If the digit is an odd number (base 10), no matter what odd base the number is in, and no matter what power the digit is in, the digit will be an odd number. It is just the opposite for even digits, (the digit becomes an even number). So in an odd base an even digit represents an even number, and an odd digit represents an odd number. In expanding a numeral you are really adding what each of the digits means.

Take the number $43265_{(7)}$ and put over each digit

whether that digit represents an odd number or an even number and it will look like $\overset{E}{4}\overset{O}{3}\overset{E}{2}\overset{E}{6}\overset{O}{5}_{(7)}$. When you add an even amount of odd numbers you get an even number so if you have an even amount of odd digits and if you add the numbers they represent you will get an even number. It doesn't really matter about the digits that represent even numbers because if you add them you will always get an even number. What really determines whether the number is odd or even is the amount of digits which represent odd numbers. If you have an odd amount of odd digits, it will be an odd number. $43265_{(7)}$ has two odd digits so it is an even number.

This completes my student's proof. When he stated "If the digit is an odd number (base 10), no matter what odd base the number is in and no matter what power the digit is in, the digit will be an odd number," he is referring to $\mathbf{O}\cdot\mathbf{O} = \mathbf{O}$. Last year one boy did this same proof. He pointed out that in a number in an odd base we have

$$a\cdot\mathbf{O}^3 + b\cdot\mathbf{O}^2 + c\cdot\mathbf{O}^1 + d\cdot\mathbf{O}^0$$

where a, b, c and d are natural numbers and $\mathbf{O}$ is any odd natural number. Since

$$\begin{aligned}\mathbf{O}\cdot\mathbf{O} = \mathbf{O},\ \mathbf{O}^3 \text{ must be } &= (\mathbf{O}\cdot\mathbf{O})\cdot\mathbf{O}\\ &= \mathbf{O}\cdot\mathbf{O}\\ &= \mathbf{O}\end{aligned}$$

Therefore he factored out the **O**'s since the important thing was their *oddness* not their numerical value he had then $(a + b + c + d)\cdot\mathbf{O}$ by distribution. The sum of these digits if even gave $\mathbf{E}\cdot\mathbf{O} = \mathbf{E}$, and if odd gave $\mathbf{O}\cdot\mathbf{O} = \mathbf{O}$. Consequently the sum of the digits determined whether even or odd applied the number in the odd base.

My student's example works on much the same idea, but it is fuller. He continues . . . "It is just the opposite for even digits" . . . referring to $\mathbf{E}\cdot\mathbf{O} = \mathbf{E}$. "When you add an even amount of odd numbers you get an even number" refers to $\mathbf{O} + \mathbf{O} = \mathbf{E}$.

Notice that his ending does not really prove his first statement, but gives us another method for determining whether or not a number is odd or even when its numeral representation is in an odd base.

Why did I go through all of this? To show you that our seventh graders are really doing mathematics . . . that is the reason. They understand numbers now. They know what numbers are all about. They can think logically. They can develop things we never thought about. This new kind of material challenges them. They are fascinated by it, and they work hard to find new ways to solve problems. I never teach a formula. They make up their own (with direction of course).

Next I would like to show you the electrical creations with which I am besieged after our discussions

Fig. I

Elements of a set

NO TRUMP	SPADE	HEART	DIAMOND	CLUB
SPADE	HEART	CLUB	SPADE	DIAMOND
HEART	CLUB	DIAMOND	HEART	SPADE
DIAMOND	SPADE	HEART	DIAMOND	CLUB
CLUB	DIAMOND	SPADE	CLUB	HEART

Explanation of Figure I

The elements of this set are the four suits, spades, hearts, diamonds, and clubs. The operation is no trump. The set has the following properties:

a. commutative—example—hearts no trump clubs equals spades, clubs—no trump hearts equals spades.
b. closure—because all of the answers are also elements of the set.
c. associative—example—(spades no trump diamonds) no trump hearts equals clubs, spades no trump (diamonds no trump hearts) equals clubs.
d. identity element—the identity element is diamonds because if you no trump diamond to any suit you get that any suit.
e. inverses—each element has one—the inverse of spades is clubs, of hearts is itself, of diamonds is itself, of clubs is spades.

of computers and the binary numerals. Some of the students use old shoe boxes and wires to make little games. One such creation had two rows of buttons and two wires. On one side were base 10 buttons, the other base 2. A light at the top of the box flashed when you completed the circuit by matching the proper base 10 symbol with its base 2 mate. By the way, this electrical apparatus was designed by a boy in roster 12, whose best friend in roster 2 taught him the binary system!

Last on my agenda are my prize posters. We discuss modular arithmetic and the properties in this system. For example mod 3 arithmetic has three elements, 0, 1, and 2. These are placed on a clock

(Continued page 125)

Intense Magnetic Fields for Research

BY DONALD STEVENSON AND HENRY KOLM

Massachusetts Institute of Technology, National Magnet Laboratory, Cambridge, Mass.
[Supported by the Air Force Office of Scientific Research]

Developments in a number of widely separated areas of research have recently inspired intense interest in the problem of achieving very high magnetic fields.

The numerous applications of high magnetic field intensity as a research environment derive from its two essential manifestations: the alignment of magnetic dipoles and the deflection of moving charges (see Figure I).

In its role as an aligning force, a magnetic field opposes the statistical forces of disorder and thus represents an environment of high order like the environment of low temperature, one in which matter assumes a state of low entropy. For this same reason a magnetic field is the tool used for reaching the lowest temperatures: one can align the dipoles in a paramagnetic salt at the lowest temperature achievable by other means, then turn off the field and let the statistical forces remove even more energy in asserting themselves. At the very lowest temperatures where the paramagnetic dipoles remain frozen for lack of energy, one can achieve even further cooling by applying the same technique to the much weaker dipoles of the atomic nuclei, providing one can generate a sufficiently high field to align them. The higher the field, the lower the final temperature reached. The quest for lower temperatures represents the earliest impetus for achieving higher magnetic fields.

The ability to align nuclei also permits "polarization" of spinning particles emitted in nuclear reactions, and such studies have recently led to the downfall of the "parity concept" by demonstrating the existence of a fundamental asymmetry in natural laws.

By observing the resonance of magnetic dipoles in a solid, one can use these dipoles as probes to investigate the internal fields of solids. Para-, ferro- and anti-ferromagnetic resonance measurements have contributed greatly to our understanding of the solid state, and many of these measurements require extremely high applied external fields to compete with the natural internal fields.

In the second of its roles—the deflection of charged particles—a magnetic field represents a loss-less confining force, one which acts normal to the direction of motion As such it has found use in the cyclotron and all other circular particle accelerators, and also serves to deflect and analyze particles of terrestrial and cosmic origin in cloud chambers, photographic track plates and mass spectrographs. An analogous application on a microscopic scale which has received much recent attention is the loss-less containment of high-energy particles in a plasma gas discharge for the purpose of achieving controlled thermo-nuclear reactions. Thus high magnetic fields are an indispensable tool for research at both extremes of the temperature scale.

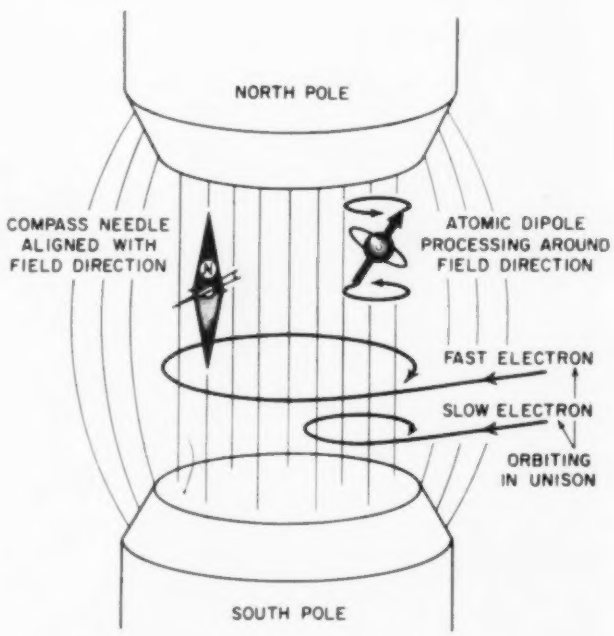

FIG. I. Alignment of magnetic dipoles and the deflection of moving charges.

The cyclotron mechanism has also been used successfully to measure the effective mass of charge carriers in solids. Since the orbital period of a circulating charged particle depends only on mass and magnetic field and not on the particle energy, identical charge carriers in a solid circulate in unison. Observation of this so-called "cyclotron resonance" at microwave frequencies, pioneered at the University of California and at the MIT Lincoln Laboratory, has yielded direct measurements of the effective masses of charge carriers in germanium and silicon, which in turn has provided valuable information concerning the energy band structure of these semiconductors. Unfortunately the microwave frequencies used were too low to permit comparable measurements in other materials in which higher defect density prevented carriers from completing an orbital rotation before being scattered. Such measurements could only be performed at substantially higher frequencies in the infrared region, and in correspondingly higher magnetic fields.

No review of magnetic research would be complete without mention of optical spectroscopy. The splitting of spectral lines induced by magnetic fields, known as the Zeeman effect, is a very striking example of the transition from classical to quantum-mechanical concepts. The effect can be ascribed classically to magnetic deflection of linearly oscillating or orbiting electrons which causes their plane of motion to rotate about the field direction, and it can also be ascribed to the precession of electronic orbits caused by the magnetic torque applied to their magnetic dipole. This duality of interpretation suggests that the basic manifestations of a magnetic field—the rotation of dipoles and the deflection of moving charges—are in fact intimately related. Quantum mechanics interprets the effect as a splitting of levels, and high-field Zeeman effect measurements provided one of the earliest tests of the new quantum theory.

Brief History of Intense Magnetic Fields

Magnetic fields up to about 30,000 gauss can be produced readily in small volumes by using electric current to magnetize iron. Beyond 20,000 gauss iron saturates and it is necessary to forego the thousand-fold amplification it provides. Higher fields must be generated entirely by circulating current. Not only does this require enormous amounts of power, but all of it must be removed as heat since an electromagnet enjoys the unique distinction of having zero efficiency.

Some experiments can be performed so quickly that a magnetic field of very short duration suffices, and it is then possible to rely on thermal inertia to keep the solenoid from melting. The maximum field intensity obtainable under pulsed conditions is limited primarily by the mechanical strength of the solenoid structure.

The earliest effort at obtaining very high fields was

FIG. 11. An experiment set up in a 2 inch Bitter type electromagnet. This magnet produces fields up to 90,000 gauss

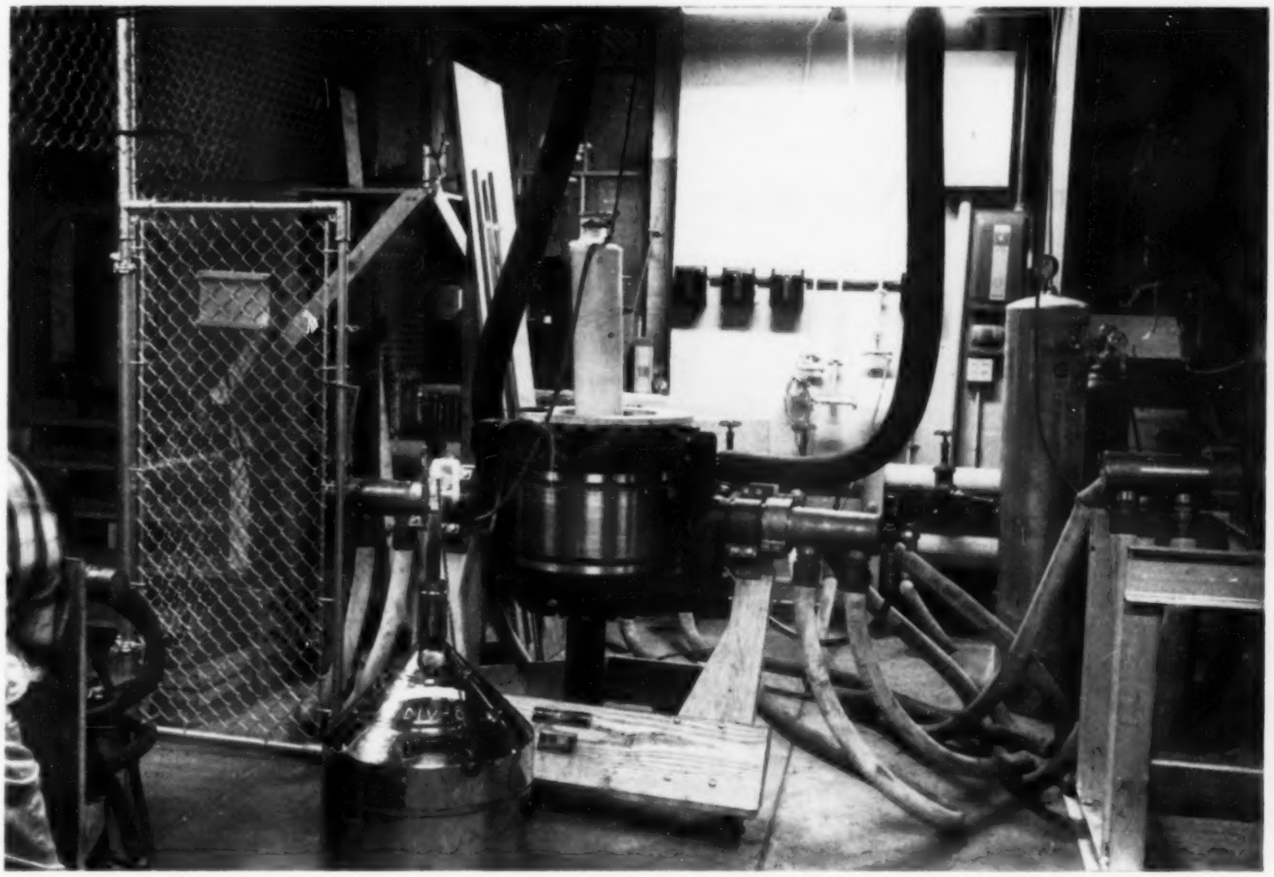

FIG. III. A 4 inch Bitter type electromagnet. The large black hoses are the water cooled electrical leads carrying up to 10,000 amperes. Cooling water is supplied through the fire hoses. This magnet produces fields up to 70,000 gauss.

undertaken in 1923 by the Russian physicist Kapitza at Cambridge University. He obtained 500,000 gauss for several milliseconds by draining a battery of storage cells through a very small solenoid, and later succeeded in producing 300,000 gauss for several milliseconds in a larger solenoid powered by the short-circuit current of a 2 megawatt ac generator. A highly ingenious mechanical switch was used to establish connection for one half-cycle, and specially designed building foundations delayed transmission of the seismic shock in order to permit galvanometers to deflect before the tremor reached them.

Kapitza used his installation to perform pioneering work in solid state physics, particle physics and cryogenics until he abruptly returned to Russia in 1934. Shortly thereafter his installation was sold to the Russian government, and the Western world lost a unique tool.

Two years later, in 1936, Bitter at M.I.T. began work on the development of a water-cooled electromagnet capable of maintaining fields of the order of 100,000 gauss continuously and over volumes considerably larger than Kapitza's. The project was formidable in its day, and its cost almost unheard-of in the realm of basic research; Vannevar Bush deserves credit for his perseverance in raising funds for the 1.7 megawatt facility. The value of the installation became apparent almost immediately upon its completion. Highly accurate Zeeman effect measurements made possible by Bitter's 1 inch caliber, 100,000 gauss solenoid provided much valuable spectroscopic data. The 60,000 gauss field in Bitter's four-inch caliber solenoid had sufficient volume to accommodate cryogenic apparatus and established a new record in low temperature experimentation.

Bitter's M.I.T. installation was duplicated at the Naval Research Laboratory in 1947, and comparable facilities have been constructed at other institutions.

The M.I.T. National Magnet Laboratory

Several years ago, workers at the M.I.T. Lincoln Laboratory, recognizing the vital need for higher magnetic fields of extended duration, began investigation to determine the feasibility of constructing continuously operating solenoids to produce higher fields than the solenoids designed by Bitter twenty years ago. A new National Magnet Laboratory has been organized by M.I.T. under contract with the Air Force Office of Scientific Research to build and operate a high field magnet research facility. Work is now in progress to provide improved research magnets for immediate use in conjunction with the present 1.7-megawatt generator at M.I.T. At the same time, the foundation is being laid for even more powerful solenoids, which will provide fields up to

(Continued page 120)

The complete historical development of Poliomyelitis Vaccine citing the major contributions in its development offers a source of valuable general background for the science teacher.

Poliomyelitis Vaccine

BY MARY JOAN VAJENTIC

Senior, School of Pharmacy, Duquesne University, Pittsburgh 19, Pennsylvania

On April 12, 1955, newspapers throughout the world headlined the news that polio had been conquered. This accomplishment was the product of years of work by many people.

When the National Foundation for Infantile Paralysis (established on January 3, 1938, to "lead, direct, and unify the fight against infantile paralysis"[1] took up the task of unifying the fight against polio, the warehouse of scientific knowledge was not entirely bare For a hundred years scientists had been interested in this scourge, trying to unearth the clues to its vicious maraudings Their efforts, however, were unorganized, frequently contradictory, and lacking the essential continuity of financial support. Despite these handicaps those early polio fighters managed to gather a considerable fund of knowledge:

> Viruses were complete parasites. In order to grow and reproduce, a virus had to enter a living cell and take over its life cycle for its own sustenance. A virus lived at the expense of its host, destroying it completely as the virus duplicated its own evil counterparts.[2]

The possibilities for extensive experimentation were limited by the fact that polio was apparently a natural disease only of man. Animals were seemingly unaffected by it. How could scientists do the hundreds of essential laboratory experiments if the disease could be studied only in its human victims? Unless polio could be studied in the laboratory, the chances of finding a preventive were slim.

The break came in 1908 from Austria when Doctor Karl Landsteiner—later to receive the Nobel Prize for his research on human blood types—made the first successful transfer of the disease to an experimental animal. Making a suspension out of the infected spinal cords of human victims of the disease, he injected the virus-laden material into healthy monkeys. Within a few days the monkeys bore fevers and were whimpering like sick children. Gradually the paralysis extended and soon they were dead of the dread disease—the first animal martyrs to polio.

[1] Roland H. Berg, *Polio and the Salk Vaccine*, Public Affairs Pamphlet No. 150A, ed. by National Foundation for Infantile Paralysis (New York, 1955), p. 4.

[2] *Ibid*, p. 6.

Now scientists had a laboratory tool to work with. Here was an animal that could be artificially infected. The search continued, however, for a cheap animal that would speed up research. The next break came in 1939 at the laboratory of the United States Public Health Service in Washington. Dr. Charles Armstrong took infected material from monkeys that had succumbed to polio and inoculated it into various wild rodents to no effect. He then injected it into a cotton rat which sickened and became paralyzed. Taking material from the paralyzed rat, he inoculated another rat. In even less time the second rat became paralyzed. Then came a crucial test. Material from the paralyzed rodent was injected into a small laboratory mouse. It too sickened with polio. The triumph was complete. Not only rats but even mice could be used for polio research. The bottleneck had been broken. Progress was possible.[3]

In the early 1940's scientists engaged in polio research were hopeful of some day developing a vaccine to prevent polio. But hopeful though they were, they realistically admitted that the hope was a mere possibility and not very probable. There were still too many unanswered questions. The theoretical vaccine would have to protect against all forms of the disease, and there was growing evidence that polio might be caused by not one but many related viruses. Was polio similar to pneumonia with thirty-odd related bacteria responsible for the diseases? No one knew how many there were, but it seemed certain that there was more than one polio virus capable of causing the same disease symptoms.

The other dismaying problem was how to obtain polio virus to be used in a preventive vaccine. Since polio virus would grow only in the living nerve cells of man and certain laboratory animals, hope for a vaccine remained dim. Doctors realized that the virus grown under such conditions was highly dangerous to use because it could not be freed from the contaminating protein material of nerve tissue in which it grew. Until these two major problems could be solved, a vaccine for polio would remain merely a dream.[4]

[3] *Ibid*, pp. 7, 8.

[4] Berg, p. 8.

It wasn't until 1948 that the scientific advisors of the National Foundation for Infantile Paralysis decided that sufficient knowledge and methods had been developed to warrant an all-our attack on the first major problem: How many different types of polio virus were there? Carefully the plans were made. Consultations were held with a special virus-typing committee. This was to be no one-man job. It would require the brains of some of the nation's top scientists and the laboratory facilities of several universities. This would be a very large research project with a three-year target date for its completion and a research expense account of $1,190,000. Various segments of the project were assigned to teams of scientists at four universities. Heading the teams were Dr. John F. Kessel at the University of Southern California, Dr. Louis P. Gebhardt at the University of Utah, Dr. Herbert A. Wenner at the University of Kansas, and Dr. Jonas E. Salk at the University of Pittsburgh.

Steadily the work ground on, and in somewhat less than the three years allotted, sufficient specimens had been classified. The report was ready. All polio viruses examined fell into three major classifications. They were Type 1 or Brunhilde; Type 2 or Lansing; and Type 3 or Leon.

The fact that there were only three major virus types capable of causing polio was heartening news. It has been feared that there might be so many types that it would be physically impossible to incorporate them into an effective vaccine. Three, however, was not too large a number. A vaccine was still possible.

> On January 28th, 1949, a briefly written report in a scientific journal signalled a major breakthrough. It was by Dr. John F. Enders of Harvard and the Children's Hospital in Boston: 'It would seem from the experiments described above that the multiplication of ...poliomyelitis virus... has occurred... in cells not of nervous origin.' That simple phrase 'not of nervous origin' electrified the scientific world. It meant that now polio virus could be grown in test tube cultures of non-nervous tissues, and thousands of laboratory experiments could be conducted cheaply and quickly without relying exclusively on expensive and difficult to maintain animals.[5]

Dr. Ender's achievement marked the beginning of the end of the "monkey era" of research. Polio research had taken a giant step forward. A test tube had been substituted for an expensive monkey. Most important of all, it meant that when and if a vaccine was developed there was now a safe source of supply for the virus that would have to go into it.

Other scientists gradually took up Dr. Enders' work while he too pursued the problem. Soon it became evident that one of the more suitable materials for growing polio virus was cells from monkeys' kidneys. Without delay Dr. Enders' findings were adapted to use in the virus-typing program which was still going on. The culture method speeded up the program so that it was accomplished ahead of schedule and at a great saving of money.

So, by 1950, two of the major obstacles to polio prevention were being overcome—it had been determined that there were three major virus types capable of causing polio, and methods of growing virus in tissue culture were improving. Still the road to a practical vaccine seemed to be blocked. They thought that the virus reached the Central Nervous System via nerve pathways and not the bloodstream. It was believed that the virus entered the body through the mouth and nose. From the intestinal tract it was picked up by tiny nerve fibers along which it traveled to the large motor nerve cells in the spine and areas of the brain. The destruction of these motor nerve cells by the virus resulted in paralysis of those muscles which the affected nerve cells controlled. The extent of paralysis depended on the amount of damage done to nerve cells. There was no evidence that at any time the virus lurked in the blood.[6]

Yet medical science well knew that vaccines against any disease are effective because the vaccines stimulate the body to produce antibodies, those chemical elements which remain in the blood and are able to neutralize specific invading disease organisms such as bacteria or viruses. Even if a polio vaccine could be fashioned that would produce an abundance of antibodies in the blood, scientists reasoned, how could those antibodies protect the body against polio invasion when the virus never enters the blood?

Hopes for a practical vaccine seemed dim in the early months of 1952 until scientists at Yale and Johns Hopkins made a startling announcement. Working independently on the same project under grants from the National Foundation, Dr. Dorothy Horstmann at Yale and Dr. David Bodian at Johns Hopkins had never been completely satisfied with the strict neural pathway theory of polio. Independently they conducted similar experiments. Infecting monkeys and chimpanzees with polio, they carefully examined specimens of the simians' blood at regular, frequent intervals. Their efforts were rewarded with success. Within four or five days after infection, and lasting but for a brief time, polio virus was present in the blood. Subsequent tests on naturally infected humans confirmed the revelation. The bloodstream was an invasion route of the crippling virus. That meant there was a potential battlefield where antibody could meet virus and defeat it. A vaccine, if

[5] *Ibid*, p. 10.

[6] Jonas E. Salk, M.D., "Preconceptions About Vaccination Against Paralytic Poliomyelitis," *Annals of Internal Medicine*, Vol. 50, No. 4 (April 1959), p. 843.

one could be made, might have a chance to succeed, but there was no vaccine as yet.[7]

There was blood, however, and blood contained gamma globulin, and gamma globulin contained polio antibodies. That had been proved by Dr. David Bodian. Working at his laboratory at Johns Hopkins University, Dr. Bodian had conducted many critical tests on monkeys which proved that they could be protected against paralytic polio if they received before or immediately after deliberate infection a small amount of gamma globulin. Studies on large numbers of persons had revealed the fact that nearly all adults' blood contained antibodies against one or more of the three polio viruses, an indication that most people become infected by polio virus at some time in their lives but recover without any clinical symptoms. Despite lack of symptoms, their blood nevertheless manufactured protective antibodies which remained on guard.

Dr. William McDowell Hammon of the University of Pittsburgh reasoned that if blood were drawn from large numbers of persons and pooled, antibodies against all three polio viruses would be present in the gamma globulin extracted from the plasma. There was already available a large supply of such pooled plasma in the hands of the Red Cross, some of which had been stored since World War II. To the immunization committee of the National Foundation, Dr. Hammon proposed his plan: A massive human field trial to test the ability of gamma globulin to protect children in polio-threatened areas. Laboratory evidence indicated that gamma globulin had the capacity to protect against paralytic polio. The serum was harmless; if it worked under epidemic conditions in the field, hundreds of children might be saved from crippling. It was a gamble that would require huge sums of money, the cooperation of doctors, health departments, and most importantly the American people; but the dividends, if it worked, would be great.

In the fall of 1951 and during the summer of 1952, Dr. Hammon and a group of experts moved into three polio-stricken areas at the request of local officials to supervise the administration of gamma globulin to the areas' most threatened children. Nearly 55,000 children participated in the unusual trial.

One important thing was proved by the gamma globulin trials of 1951 and 1952: If polio antibodies were present in the blood at the time when virus tried to invade the blood stream, even a small amount of antibodies would neutralize the invader and would help protect the individual against disease. This told scientists that if a vaccine could be developed that would place antibodies in the bloodstream and keep them there, then the vaccinated person might be protected against paralytic polio.[8]

In the meantime, the shadow of more dramatic events to come was growing ever larger. Early in 1951 Dr. Jonas E. Salk at the University of Pittsburgh had completed his role in the important virus-typing program. During the course of that study he had had an opportunity of working with the Enders' method of growing polio virus in tissue. Realizing that recent scientific advances had provided the essential tools for a direct attack on the problem of polio prevention, Dr. Salk requested funds for developing a practical method of inducing artificial immunization in humans. In short, Dr. Salk wanted funds to develop a vaccine. The National Foundation granted him the money.

After two years of steady work Dr. Salk reported preliminary success. The virus was harvested, purified, and placed in a watery solution. Next came the process of treating the virus so that it became non-infective yet retained sufficient strength to induce the formation of antibodies when injected. Delicately, this was accomplished by exposing the virus to a solution of formaldehyde. Finally, the inactivated virus solution, composed of equal portions of all three viruses, was a vaccine.

In March 1953, Dr. Salk reported results obtained by vaccinating about 160 children and adults in the Pittsburgh area. Blood samples revealed that the vaccine had stimulated the production of antibodies capable of neutralizing all three types of polio virus. None of the persons vaccinated had suffered serious reactions or side effects. So certain had Dr. Salk been of the vaccine's safety that his own three children had been included in the group of children whose parents had permitted them to volunteer for the first trial.

Plans were now made for a mass field trial of the Salk vaccine. The crucial problem was who would manufacture the large quantities of vaccine needed for the field trial. The National Foundation offered no subsidies but merely to purchase at cost a quantity of vaccine from each manufacturer. This involved a considerable investment of money and facilities for each firm. Eli Lilly, Parke Davis, Pitman-Moore, Wyeth, Cutter, and Sharp and Dohme were the six firms licensed by the Public Health Service on April 12, 1955, to manufacture the Salk Vaccine.[9]

Sufficient vaccine was produced by spring to assure enough for a mass field trial. Counting those who received injections of vaccine or placebo shots, and those who were merely observed, the field trials encompassed over 1,830,000 children. This was the largest study of its type ever undertaken to determine the validity of a vaccine. The first inoculation

[7] Berg, p. 12.

[8] *Ibid*, p. 16.

[9] *Ibid*, pp. 17–20.

in the nationwide field trial, which was held in 44 states, was given on April 26, the final shot about June 15.

The vaccine's estimated effectiveness in protecting against paralytic polio was 72 per cent—a satisfactory figure considering the fact that no vaccine is or can be 100 per cent effective. Also to be remembered is that this vaccine was new and could be improved. On the debit side the report showed that the vaccine failed to perform equally against all types of polio virus. It was less effective against Type 1 virus—the most frequent cause of the clinical disease than against the other two types. A possible explanation for this limitation may be the fact that the preservative used in the vaccine had a chemical effect that lessened the potency of the Type 1 component. This now has been taken care of by substituting a new type preservative.[10]

Would it be safe to vaccinate children during a polio epidemic? The question arose as a result of an observation by a group of English and Australian Physicians. These doctors noticed that a significant number of children who developed paralytic polio had a history of recent injections with diphtheria and tetanus toxoids, pertussis vaccine, and the like. Usually, the paralysis centered in the arm or leg in which the child had gotten the injection. This, the doctors called the "provocation phenomenon." Why and how often it occurred, the doctors were not certain.

There are theories that attempt to explain. During a polio epidemic, scientists point out, polio virus is widespread in the community and may be present in the intestinal tract of many children as well as adults who show no symptoms of disease. These are healthy carriers. For some unknown reason, the virus is present in the digestive tract but does not further invade the body. A kind of delicate truce exists between the virus and the carrier.

Some scientists believe that this delicate balance between host and virus may be upset by a sudden shock which transforms the harmless infection into a disastrous illness. The shock triggering the change, they say, may be an injection of diphtheria or tetanus toxoid or some other preparation. In the laboratory, scientists can duplicate this phenomenon at will. The small rodent-type animal, the hampster, is ordinarily resistant to experimental polio. Fill him full of deadly polio virus, and nothing happens, but give the animal a shot of cortisone before the injection of polio virus and quickly he will succumb to crippling polio.[11]

Whatever the cause, the "provocation phenomenon" is a real problem to local health officers and family physicians. It is impossible to gauge how often it occurs; therefore, they are unable to measure the risk.

Should one take advantage of the Salk vaccine? Much could be said on both sides, making it difficult for one person to take all the factors into consideration and arrive at a decision;

> Therefore on June 18, 1955, the National Foundation called together a group of twenty-six physicians, health workers, and experts on virus diseases to consider this problem and to provide some guidance to puzzled health officers and family physicians. After many hours of discussion the unanimous opinion was that 'the total preventive effect of the vaccine in a period of rising poliomyelitis incidence should be much greater than the possible hazard from the provoking effect of the injection.' They advised avoiding vaccination for those having fever or other symptoms of illness and also for members of a family in which a polio case has just been diagnosed, since it can be assumed that other members of the household have been infected with polio virus at that time. But the advantages to be gained from vaccination of others, they believe, are greater than the possible risks involved.[12]

That was in 1955. In the June, 1959, issue of *The Journal of Hygiene*, Mr. Lewis B. Holt stated:

> The variables operating in respect of the risk of provoking paralytic poliomyelitis by inoculating children with different prophylactic reagents have been analyzed. It is concluded that the use of combined diphtheria fluid toxoid and pertussis vaccine, administered in early infancy, incurs a minimal risk and is to be recommended because of its immunological efficiency, its unquestionable value in helping to maintain a high immunization rate against diphtheria in the child community and for its marked administrative convenience.[13]

At the present we can summarize our knowledge of poliomyelitis. We know it is a common, highly contagious virus infection with only about one per cent of the cases clinically recognized as such. The other 99 per cent of the cases appear as inapparent infections, mild nonspecific illnesses or disorders producing signs of meningeal irritation without paralysis. The disease is probably transmitted by human contact, but it is not clear how this occurs. Transmission of the disease probably occurs through the fecal-oral or respiratory routes or both.

Four clinical types of poliomyelitis have been recognized: (1) Inapparent Infection in which an individual may harbor a polio virus infection and yet

[10] *Ibid*, p. 24.

[11] Berg, pp. 26, 27.

[12] *Ibid*, p. 28.

[13] Lewis B. Holt, "A Re-Assessment of the Risk of Provoking Paralytic Poliomyelitis by Making Prophylactic Inoculations Against Diphtheria and Pertussis," *Journal of Hygiene*, Vol. 57, No. 2 (June, 1959), p. 160.

be unaware of any illness. Perhaps 95 per cent of the cases occur in such a form. (2) Minor Illness in which the infection may be manifest as a minor non-specific illness which may last for several days. (3) Nonparalytic Polio; and (4) Paralytic Poliomyelitis which emcompasses Spinal and Bulbar Poliomyelitis.[14]

Evidence of the success of the Salk vaccine prepared from formaldehyde-killed, tissue-culture-grown polio virus is accumulating. The immunity produced by this vaccine does not prevent gastro-intestinal infections with the polio virus. Since it appears, however, that the bloodstream is the route by which the virus invades the Central Nervous System, the circulating antibodies which result from the vaccine probably prevent this invasion. Hence, vaccination, although it does not prevent enteric infection with the polio virus, will prevent nerve damage and paralysis and at the same time allow a boost of immune mechanisms to develop as a consequence of the infection.

Reports from the 1957 immunization season suggests that the vaccine has been nearly 90 per cent effective in the prevention of paralytic poliomyelitis. (An improvement since the 1954 field trial in which the vaccine was 72 per cent effective.) It also gave some indication of the duration of this protection—at least three years. We cannot specify any exact length of time, however, for as Dr. Salk stated in 1959:

> It is clear from all that has been said that contrary to the expectation of some, the duration of immunity induced by a killed-virus vaccine is not evanescent and may, in fact, be much more prolonged than anticipated even by those who have been among the more optimistic. The effects observed may be explained, in part, by the properties of the polio virus that render it a particularly effective antigen. The full duration of persistence of immunity induced in this way will be revealed in time.[15]

At present, the recommendations for vaccination are an initial injection of the vaccine followed in four to six weeks by the second injection. An interval of seven months is allowed to elapse between the second and third injections in order to provide an opportunity for a hyperreactive state to develop.

It is now known that not all persons have an optimal antibody response following the administration of three properly spaced doses of the vaccine. Also, antibody levels produced by vaccination in infants and younger children do not rise as high or persist as long as in older children. For these reasons, a fourth injection of the vaccine is advisable in such individuals. However, since the physician cannot be sure which of his patients may not have responded with adequate antibody formation following basic immunization, and since there is no known danger in repeated injections, he may wish to give all his patients a booster injection one year following the third dose.[16]

Striving toward the complete destruction of poliomyelitis, scientists are also experimenting with different types of vaccines. Though an individual vaccinated with the Salk vaccine can expect protection from paralysis, the use of the killed vaccine will not affect transmission of virus from person to person.[17] The live virus vaccine, the Sabin vaccine, which is now in experimental stages aims at curbing the spread of the polio virus.

Between October, 1958, and early September, 1959, about 11 million children outside the United States received by mouth a vaccine prepared from strains of polio virus that had been selected and studied in the United States by Dr. Sabin.

At the September meeting of the European Association Against Poliomyelitis, Dr. V. Skovranek of the Ministry of Health of Czechoslovakia reported that the seasonal increase in paralytic poliomyelitis occurred as usual, during the months of July and August, in the regions of the country where three or four doses of Salk vaccine had been administered to most children but not in those where live polio virus vaccine had been given between December, 1958, and February, 1959, to only about 140,000 children out of a total population of all ages of about 2,600,000. Professor M.P. Chumakov of Moscow in a personal communication, reported as follows: "By September first total number vaccinated with Sabin vaccine exceeded 10 million, including 8,680,000 with vaccine prepared in Moscow. In Estonia and Lithuania number of polio cases in June, July, and August ten times lower compared to average for same period in many years."[18]

These observations, made during the summer months in Czechoslovakia and the U.S.S.R., provide the definitive information that was being awaited regarding the safety of this live polio virus vaccine not only for those who receive it but also for those who become immunized by contact infection. The occurrence of several thousand cases of paralytic

[14] *Physician's Bulletin*, Eli Lilly and Company, Vol. XXIV, Number 3 (April 1, 1959), pp. 84, 87.

[15] Jonas E. Salk, M.D., "Vaccination Against Poliomyelitis: An Ounce of Prevention," *Royal Society of Health Journal*, Vol. 79, No. 4 (July-August, 1959), as found in *Collected Reprints on Research by Grantees of the National Foundation* (1959), Vol. XX, Part II, Sec. 136, p. 321.

[16] *Physician's Bulletin*, p. 87.

[17] Jonas E. Salk, M.D., "Preconceptions About Vaccination Against Paralytic Poliomyelitis," p. 856.

[18] Albert B. Sabin, M.D., "Status of Field Trials with an Orally Administered, Live Attenuated Poliovirus Vaccine," *Journal of the American Medical Association*, Vol. 171, (Oct. 17, 1959), pp. 863-868.

(Continued page 119)

The following is an article of the "How to Do It" variety suitable for the secondary school science course.

Polyvinyl Chloride Dispersions–Plastisols for Industry

BY ROBERT F. McTAGUE

Technical Director, Stanley Chemical Company, East Berlin, Connecticut

Introduction

In the year 1960 approximately 200 million pounds of polyvinyl dispersions, or more commonly called "Plastisols," were used by American industry. It is the purpose of this demonstration to show how a simple plastisol formulation can be made and how this plastisol is used in industry.

Definitions

Plastisols are dispersions of polyvinyl chloride resins in organic liquids, such as dioctyl-phthalate. These polyvinyl chloride resins are termed dispersion grade. The liquids are called *plasticizers*, because they soften and impart flexible characteristics to the finished compound.

At room temperature plastisols are liquids and free flowing. At elevated temperatures (300–400°F.) the plasticizing liquid solvates the resin particles, and the mass becomes a solid solution. In industry this phenomenon is utilized to make many articles ranging from toys to footwear, prosthetic devices, textile and paper coatings, corrosion resistant screening, foams and sponges for automotive and upholstery, imitation leather for pocketbooks and jackets.

A simple recipe can be made in the following manner:

1.	Dioctyl phthalate	60 parts by weight
2.	Epoxidized soya bean oil	10
3.	Dispersion grade PVC	100

The above recipe can be mixed with an electric or air mixer for approximately 10–15 minutes to obtain a smooth paste. In industry it is standard practice to evacuate the air from this mixture by pulling a vacuum on a closed container of the plastisol. At 29.5 inches of vacuum this air evacuation is accomplished by spreading the plastisol in a thin film on a spinning disc in a vacuum atmosphere.

We are now ready to simulate a process that is used in industry to make thousands of pairs of storm boots, overshoes, etc., and the millions of dolls' parts that are made in this country.

Equipment

An oven operating at 400°F.
Rubber extraction flask (250 ml.)
Beaker tongs
Plastisol (as made above)

Technique

Place the clean rubber extraction flask in the oven for one minute at 400°F. Remove the flask and fill it to the top with the prepared plastisol. Allow plastisol to remain in flask one minute and then pour out. Allow it to drain 2–3 minutes. Put flask back in oven, and allow it to fuse until the film clears. In circulating ovens this will take only 4–5 minutes. In a static oven it might take 15 minutes. Remove flask, allow to cool until warm to handle, and then strip out of the glass mold.

Added Notes

1. You may pigment the compound by adding 1 to 2% by weight of artists' oil colors.
2. The longer you leave the empty flask in the oven before filling with plastisol the heavier the wall thickness of the final plastisol skin.
3. You can coat the outside of the flask by dipping the flask into the plastisol, and baking. Some instrument companies are coating flasks in this manner for its safety features.
4. Preheating the mold allows some plastisol to gel (not fuse) to the wall of the mold. The final heat allows it to fuse.

Some Suggested Sources

1. Dioctyl phthlate. Monsanto Chemical Co., St. Louis, Mo.; Union Carbide Chemicals Co., N. Y., N. Y.; Pittsburgh Chemical Co., Pittsburgh, Pa.
2. Epoxidized Soya Oil
   Admex 710, Archer-Daniels, Midland, Minn.
   G—62. Rohm & Haas, Philadelphia, Pa.
   JPO. Union Carbide Chemicals Co., N. Y., N. Y.
3. Polyvinyl Chloride Resin
   Geon 121. Goodrich Chemical Co., Cleveland, Ohio
   QYNV. Union Carbide Plastics Co., N. Y., N. Y.
   Opalon 410. Monsanto Chemical Co., Springfield, Mass.
   Exon 654. Firestone Plastics Co., Pottstown, Pa.
   Marvinol VR-50. Naugatuck Chemical Co., Naugatuck, Conn.
   PV-70. Diamond Alkali, Painesville, Ohio

References and Guide Books

1. *Plastics Engineering Handbook*—3rd Ed. 1960. Reinhold Pub. Corp.
2. All above industrial concerns have many brochures and booklets on the subject of plastisols.

A reexamination of the curricular offering in chemistry is one important aspect of education Prof. Umbay H. Burti discusses. He offers some important considerations to teachers in his article.

Constructive Conservatism and the Chemistry Curriculum

BY UMBAY H. BURTI

University of Scranton, Scranton, Pennsylvania

"If I cannot reform with equity, I will not reform at all." This quotation from the works of Edmund Burke is appropriate as an introduction.

The literature is currently suffering from a surfeit of reform as regards curriculum for Chemistry taught in the Undergraduate College. An examination of the situation as it now exists indicates, at least to us, that the answer to what may be wrong with science courses in general and Chemistry in particular, is that the wrong things are taught in the wrong places, and, sometimes, to the wrong students. It has occured to us then, that an article such as this is timely, and that perhaps, by pointing to the approach taken by the Chemistry Department here at the University of Scranton during the last eight years, a constructive method for the preservation of those proven values which the standard classical program possesses will be called to the attention of interested persons. In addition, the value of a conservative approach to change in course content has been somewhat overlooked. Constructive conservatism rather than revolution has, we believe, been proved to be eminently workable in our program.

At present, the standard program for Chemistry Majors at Scranton is as follows:

Freshman Year—General Chemistry & Qualitative Analysis—8 credits

The experiments of the first semester and part of second semester are, for the most part, of a quantitative nature. The remainder of the second semester is taken up with semi-micro qualitative analysis.

Sophomore Year—Quantitative Analysis—Instrumental Analysis—7 credits

The first semester is devoted to the basic work of a first course in Quantitative Analysis with the typical volumetric and gravimetric analyses conducted in the laboratory. The second semester covers work dealing with the use of Titrimeter, Photoelectric-colorimeter, Electroanalyser, pH meter, Polarograph, Flame Photometer, Kjeldahl Analysis and Spectrophotometer. Principles involving these instruments are treated in lecture.

Junior Year—Organic Chemistry—8 credits

Aromatic and Aliphatic chemistry is treated simultaneously; considerable stress is placed on Kinetics and Mechanisms. The integration of aromatic and aliphatic presentation provides for greater facility in planning a schedule of laboratory experiments.

Junior Year—Physical Chemistry—8 credits

Senior Year—Electives—20 credits

The electives consist of the following:

First semester	
Chemistry Seminar	1 credit
Introduction to Chemical Literature	1 credit
Advanced Organic Chemistry	3 credits
Biochemistry	3 credits
Advanced Physical Chemistry	2 credits
Second semester	
Undergraduate Research	2 credits
Qualitative Organic Analysis	3 credits
Physiological Chemistry	3 credits
Thermodynamics and Kinetics	2 credits

A minimum of 8 credits of electives besides the four basics will satisfy the chemistry requirement for a Chemistry Major. You may note that the four "Basics" are maintained and followed in the usual sequence and order, with the variety of "Electives" in the Senior Year. We have purposely placed quotation marks around electives because complete freedom of choice is not granted to the student. At the same time, in the above, we have recognized that something must be added if the objectives of the department are to be attained, and in this regard we have attempted to flesh out the bare bones of the program. All students, for instance, are required to take the course in Introduction to Chemical Literature and the Chemistry Seminar in the Senior Year. In those and in other courses in the upper division, research attitudes and states of mind are stressed. Further, in all upper division courses, "spoon feeding" of students is not practices. The emphasis

throughout is on independent thinking, professional attitudes and work habits.

Beginning with the upper division years, i.e., the Junior year, all Chemistry Major students are subjected to a series of fourteen cumulative comprehensive examinations in Chemistry. These examinations are given once each month during seven months of the academic year, and are administered by all members of the faculty on a rotation basis. The subject of the examination is not announced beforehand, and consequently mastery of these examinations is accomplished only by a reading program in depth over and above course work on the part of the student. It is required that the student pass eight of the fourteen examinations given over the two year period; the results of these examinations weigh heavily in the recommendation of students for graduate study.

The department has, in addition, instituted a program of undergraduate research for selected students. The selection of candidates for the course begins with an announcement through the bulletin board during the beginning of the school year—an announcement to the effect that those interested will register with the department head. Those indicating a desire to participate are evaluated by each member of the Chemistry Department staff. Candidates are selected on the basis of their academic record, the results of the cumulative examinations, and the subjective evaluation by the various members of the department. The students so selected are assigned to a mentor and given a problem to investigate. The work required on the problem will be, generally, for a period of not less than one semester. At the conclusion of this work, a thesis is prepared by the student, and defended in an oral examination against the entire Chemistry Faculty. In recent years this phase of the program has been augmented under a grant for undergraduate participation in research, awarded by the National Science Foundation.

As an added feature of the Chemistry Program, entering Freshmen in the Chemistry curriculum are given a placement test in Chemistry within the first week of the Fall Semester. The test administered is the A.C.S. Cooperative Test for High School Students. All students meeting departmental standards in this test (and the standards are admittedly high) are relieved from the obligation of attending regular classes and laboratory exercises in Chemistry 1. Rather, these individuals are immediately embarked on a program of supervised laboratory work of an advanced nature and a program of independent but supervised study on a tutorial basis. In this program, the students selected are rotated for the semester on a tri-weekly basis to all teachers in the department for special tutorials on advanced phases of the *same* material covered in the regular Chemistry 1 curriculum. Emphasis is placed on such topics as the History of the Development of Chemistry, Atomic Orbitals, Extension of the Gas Laws, etc. In addition, the student must be subject to the regular final examination in Chemistry 1 plus examinations and papers as required by the Faculty. Final grades for this course are proffered on the basis of faculty consensus and upon the results of the examinations taken. This phase of the program is obviously an effort to "stretch" the better student to the limit of his intellectual capabilities. We are happy to say that this endeavor has met with enthusiastic response on the part of both the faculty and the students. This independent studies program within the framework of Chemistry 1 may, in the future, be continued in the second semester of the Freshman year also, and will, in any event, be expanded to encompass additional students in future years.

In conclusion then, it can be seen that the framework of the traditional curriculum in Chemistry has been preserved, but more than this, it has been strengthened by the application of a practical modern approach, designed to close the gap between the academy and industry and the graduate school. The results have been promising and worthwhile both to the students and to the faculty.

MICROBIOLOGISTS

These biologists concentrate on the invisible world, which includes bacteria and those plants and animals which can be seen only through a microscope.

Among the microbiologists are Bacteriologists, who investigate bacteria; Protozoologists, protozoa; and Virologists, viruses. Microbes are the object of attack or use by Immunologists, who develop vaccines, toxoids, and other biological products; by Epidemiologists, who help to control contagious diseases by testing milk, water, and food, and by Dairy Bacteriologists who are concerned with the production of cheese, butter, and yogurt.


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THE LAWS OF OPTICS HOLD FOR STUDENT MODELS TOO For a beginning student, any enlarged image seen through the microscope will appear exciting. But isn't it just as important to see a *correct* image? A *true* picture? Magnification without resolution is empty . . . the image appears blurred and details are fringed with diffraction lines in much the same way as a faulty TV picture. That's why UNITRON *doesn't offer* a 'student series' of objectives which, though named to imply "achromatic", still let color and aberrations in through the back door. *All* UNITRON Student Microscopes are equipped with the *same professional-type objectives* supplied on our more expensive medical models. Because our high-dry 40X objectives and condensers each have a numerical aperture of 0.65, the student can enjoy the same quality image at 400X or 600X that the medical student sees through his more expensive instrument.

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(illustrated with optional illuminator)

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SUBSTAGE — .65NA condenser, iris, filter holder, and mirror

PRICE* — $118 ea. . . . $106.20 ea. in lots of 5–10.

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Paper delivered at 1961 Annual Meeting of the Pennsylvania Catholic Round Table of Science.

The Importance of Research in Academic Institutions

BY CORNELIUS W. KREKE

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In a recent article (*Science 133*, 362 (1961)), Heist, McConnell, Matsler and Williams reported the results of their studies on the importance of the school on the productivity of scholars (scientists and others) and concluded "that students of high ability attending highly productive institutions have a pattern of traits, values and attitudes which is more closely related to serious intellectual pursuits than have students of high ability attending less productive institutions."

The sample of students for these studies, 956 in number, both men and women, were winners and near winners of the National Merit Scholarship certificates in 1956. These were mailed questionnaires before entering college and after the first year. Their careers were then followed in graduate schools, noting the number of Ph.D. degrees, fellowships, etc.

I must say that I was pleased with the results of this study because after reading Darley's article delivered in Lawrence, Kansas in 1956 at the 38th Conference of the National Association of Student Personnel Administrators, stating, "Without cynicism, one might state that the merit of certain institutions lies less in what they do to students than it does in the students to whom they do it", and also Holland's paper (*Science 126*, 433 (1957)) who found that the colleges which are noted for the production of future scientists and scholars started with students who had a greater indication for the intellectual life, I wasn't sure just how much influence we teachers have, if any.

It was found in the work of Heist, et al. that scores from students from the high productivity colleges indicated more freedom and receptivity to learning, more objectivity, more originality and less conservatism. Also, a greater number of students placed in the theoretical, abstract and scientific categories while students from the low productivity schools placed high in the applied, technical and business categories.

A natural explanation or, I should say, hypothesis for the high productivity of some schools is undoubtedly a happy combination of expectations of both students and faculty and, in this connection, Thistlewaite (*Science 130*, 71 (1959)) states that productive colleges have rather special cultural characteristics and these characteristics he showed to be different as the scholars produced are scientists, social scientists, humanists. Heist and his co-authors point out that faculty interest and values are essential in the production of scientists and scholars.

I reviewed quickly this article of Heist and coworkers because as teachers we are concerned with the production of scholars, especially scientists. I am using the term "scientist" here very broadly to mean the professional man or woman of science. I am not identifying scientist here with research scientist in contradistinction to teacher of science or industrial scientist but including all of them, adding that there be a mature interest in the chosen field and a desire to advance the field. I do, then, make a distinction between scientist and technician. A technician is one who either lacks a mature interest or has no desire to advance the field.

In spite of everything we do, there will always be some students who have no interest in rising above the technician level but in our efforts to produce the professional scientist or to orient our students toward this goal, our own research is of prime importance; that is, as Heist points out, our own interests and values may be the difference. This remark seems inappropriate at this meeting since all of you are actively engaged in research programs and have for some time already realized the fruits of your work. But, apparently, all teachers of chemistry are not thus inclined. Twenty-five years ago, Carlson wrote (*Science 65*, 125 (1927)), "Students may complete their education without having to solve problems where the answer is not known." Dwight J. Single in his article entitled "Psychological Barriers in Research" (*Am. Sci. 42*, 283 (1954)) only six years ago wrote that this is true of many institutions today.

Particularly disturbing is the statement of G. B. Kistiakowsky to a conference at Mount Holyoke which was quoted by the *New York Times* (see R. E. Gibson, "The Arts and the Sciences, *Am. Sci. 41*,

397 (1953)). "I see ourselves threatened with a generation of scientific workers who know how to carry out instructions and to follow in the footsteps of others, but who have not learned how to discover a rewarding research problem, how to plan the attack on it and how to solve it. And whether we are training the student for industrial leadership or perchance for a life of a college scientist, we are not doing a good job this way."

Perhaps the term "research" covers a multitude of activities in which some teachers are engaged which are all of value but are missing something when we consider student benefit. It might be well to examine various attitudes of research in the light of student benefits. While a student might be taught to run an instrument and produce a lot of data which leads to regular publication by the professor, such activity is of questionable value in the light of Heist's findings that the schools producing scholars emphasized freedom of thought, originality, creativity, abstract thinking etc.

1). First, there is the pragmatist who may tell you that research consists in proving the obvious in a most thorough manner by laborious means. This may be the attitude of the inventor. This person is either skeptical as to the value of research itself or ties in research with practical attainments.

Thomas Edison is reputed to have little respect for the Ph.D.'s or the "professors" as he called them. When one of his engineers asked him how he expected to have the storage battery work, he is supposed to have answered that he didn't care how it worked. We'll invent one and let the "professors" figure out how it works.

He is also reputed to have had his fun with the professors who applied for a position in his organization by asking them to determine the volume of an incandescent bulb. When after lengthy mathematical calculations they arrived with the answer, he would check their answers in their presence by pushing the bulb in water and noting the volume of water displaced.

I have another person in mind who happens to be a successful researcher, having recently discovered a new antibiotic. When he was asked about the value of the various kinds of research, he answered that he considered two kinds—the worthwhile and the academic. Both of these views seem to me to be slanted too much to the practical to be of great value to students.

2). Another may tell you that research means looking again very carefully. As an analogy, suppose a man is looking for a particular favorite tie. After fumbling through drawers for fifteen minutes or so, in desperation he calls his wife who quite calmly approaches the right drawer and picks it up. Research is that simple that all you need is a method and time to do it. I think this type of person is exemplified by one who considers research a matter of grinding out data.

3). Still others may say that a researcher is a person who does not know what he is looking for but is not happy until he finds it. I think this is the attitude of those outside science—administrators, maybe, who think of research as a hobby such as collecting mineral specimens or biological fossils.

4). Still others outside of science—probably scholars in other fields—may tell you that research is a creativity similar to art and not worthy of the scholar. These, I think, confuse science with technology and think of it as development rather than as a search for understanding.

Now while there may be some truth in all of these attitudes, we all know that there are two fundamental requisites in research—the idea and a quest for understanding.

Consider the value of the idea first. A disciplined imagination is at the bottom of every discovery. The person professing to do research must be looking for something. He may not know exactly what he is looking for but he is conversant enough with the situation under scrutiny to recognize the presence of an unsolved problem. He has an idea of what he is looking for.

If a person with an idea also possesses a capacity for critical analysis, he is at least partially equipped to solve the problem. If he is also master of a technique or method which can be used in the investigation, he is on the way to the solution. Frequently, these abilities are not associated in one person. Then, the lacking ability must be developed or, as sometimes happens, two or more persons combine talents.

But besides these abilities there is something more fundamental that is required for successful research—the characteristic which is of prime importance. This, I call the proper attitude of mind. The desire to understand—the desire for more knowledge—the desire to contribute to the patrimony of knowledge. There are those who have the ability to do research but do not have the intellectual curiosity; therefore, no research is done. The strength of this drive will insure progress in spite of the most trying of obstacles.

From the student's point of view, undoubtedly, the primary motive that impels an undergraduate to become a graduate student is the desire for more learning and instruction in a field that appeals. This is the right attitude. This attitude we must encourage and develop. The thoughtful graduate student quickly recognizes his obligation to contribute to the reservoir of knowledge from which he has been drawing information. Students who fail to get beyond the spoon-feeding phase never attain mature intellectual growth. The student with an appetite

for knowledge soon learns that occasional feeding by his teacher does not appease his intellectual hunger and so learns how to feed himself. This is where research programs are so vital. Moreover, his conflict with unsettled problems drives him on and soon he is consumed with a desire to add to knowledge. It becomes the absorbing interest in his life.

Teachers who have developed this drive themselves realize the importance of research for a full satisfying intellectual life. They realize, too, that the inspiration is not something you can get just by reading books on how to do research. It is more like a highly infectious disease that can be transmitted by contact—working with the master. Dwight Single in his paper "Psychological Barriers in Research" (*Am. Sci. 42*, 283 (1954)) says what is needed is research upon the researcher—an investigation of what native and acquired attributes contribute to the success of the research. Undoubtedly, it is possible to find out what a researcher did if he is successful in his project and it is possible to find out what a teacher did if he is successful in producing scientists but no amount of investigation of this kind will supply the inspiration and the drive to do it.

So, if we are interested in producing mature, intellectual scientists with a consuming desire to understand, we must have it ourselves. We cannot insist on its being essential for the student if it holds no interest for us. Perhaps Portia in the *Merchant of Venice* gives us the instruction. "If to do were as easy as to know what were good to do, chapels have been churches and poor men's cottages princes' palaces. It is a good divine that follows his own instructions. I can easier teach twenty what were good to be done than be one of the twenty to follow mine own teaching."

Now research is not an activity which is conducted only for the sake of the student. I believe that research gives enlightenment and meaning to our teaching also. As B. G. Folsom said in his article "The Academic Institution's Concern with Future Patterns of Research" published in *Am. Sci. 46*, 169 (1958), "If no research activities are undertaken, the teaching faculty tends to teach ancient history." This seems extreme and Folsom was confining his remark to engineering. But he has a point here which I think is true for other fields of science as well and that is the importance of the orientation of the teacher—will it be backward or forward?

I believe, too, that the discussion of controversial issues associated with our own field in the classroom affords problems and ideas for research so that teaching and research offer reciprocal advantages. I do not believe that we can look upon it as an extracurricular activity any longer. It is vitally bound up with our teaching. I want to make a point of this because many of our college science teachers still do not recognize the value of research.

Now, if my point is clear and the analysis accurate, I believe that there are many who would agree with me in principle. They realize the value of research but do not conduct it themselves. They will say, "We agree that research is important both to the teacher and to the student but there are so many obstacles we cannot overcome. We do not have the time, or the equipment, or the support, or we don't know exactly what to do."

Now, they may have a point. In the report of the Wooster Conference June 22 to July 2, 1959 on "Research and Teaching in the Liberal Arts College," the summary of their findings on their project proposal directed toward the identification of those qualities and advantages enjoyed by productive colleges (research production) was as follows:

The productive departments:

1. Have greater number of Ph.D.'s.
2. Have greater number of chemistry majors.
3. Have lower course loads in contact hours, thus providing more faculty time for research and study.
4. Have larger chemistry libraries—more journals—library housed in department.
5. Are provided with departmental services—stockroom order clerk, secretarial help.
6. Departments are made up of teachers who are concerned with a greater degree of professional activities—American Chemical Society, Chemical Education, etc.
7. More of their students go on to Ph.D.'s.
8. Students participate in seminars and regional meetings.
9. Adequate laboratory space and equipment.

I guess all of us can find our own obstacles in reading these findings. I suppose we all have one or another of them and we will never have things as perfect as we would like them. But the question is why should the obstacles add up to such a barrier that no research is conducted? Or, to put it another way, do all these advantages add up to a guaranteed research? We know they do not—advantages sometimes may even lead up to hardships. Many times it happens that a person receiving an expensive new piece of apparatus finds that it imposes a limitation because he feels that he must develop his research around the instrument.

There was a make-believe story printed in *Chemical and Engineering News* some years ago which brings out this point. The president of the company visited their laboratories to find a Ph.D. washing apparatus. As I remember, the president said, "Now doctor, your time is too valuable for this. I'll hire

(Continued page 126)

The handling of individual differences is a perennial problem confronting the teacher. Mr. Ricker's suggestions to the elementary science teacher should be of considerable help.

Organizing Materials for Individualized Science Teaching in the Elementary Grades

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A science program should help children learn science concepts, generalizations, or the "big ideas" as often called. This is one of the fundamental goals of an elementary school program. Teachers utilize many kinds of materials to assist the pupils in acquiring this science information. The materials are used at all levels of the learning process and for different reasons. As a pupil progresses, his concepts become more and more refined. Thus, a primary child might learn the descriptive qualities of magnetism while working with magnets, but a sixth grader might learn how magnetism is related to electricity while using similar magnets.

There are two factors which a teacher should not overlook when organizing the materials for the classroom. Every child in the room will not be at the same level of conceptual development. Each pupil will not react in the same way to the apparatus which is used as a learning device. The second factor concerns the establishment of a purpose. A student should have a purpose in mind for using the equipment. With a goal to act as a guideline, the student should be able to utilize the materials in a more effective and efficient manner. In essence, this means materials organized for individualized and definite learning activities would enable the teacher to consider the varying abilities, interests, and needs within the classroom.

A teacher can turn to the "shoe-box" science kits or the science concept kits as a starting point in organizing science materials to accomplish the above objectives. By using these general kits it is possible to develop five basic types of specific "learning" kits. Each "learning" kit presents a pupil with a definite science problem for which he can make a tenative or possible conclusion by utilizing the materials found in the box and the science information he has acquired in previous lessons.

The five basic types of problem-solving kits and their characteristics are given below. Possible variations and examples are also briefly described.

(1) Problem-solving kit for illustrating science concepts. The materials which will allow a child to repeat a demonstration done by the teacher or a small group of students are placed in a small box. This enables a pupil to demonstrate or illustrate a science concept to himself at a later time.

For example, consider a fifth grade class that is concerned with the problem, "How can the strength of an electromagnet be increased?" The class, working as a group and under the guidance of the teacher, might reach a solution by using a box of tacks, two dry cells, wire, and a large nail. The teacher might then wish to give every child an opportunity to use these materials individually as he tries to solve the problem by himself. The equipment can be placed in a small box and then set on a book shelf. The pupils could sign out the kit as they do a library book. A small card in the box can indicate the problem that is to be solved, and give possible suggestions for solving the problem. The students should be encouraged to write down the solution they reach, and check it with an answer card kept in a filing box located in a convenient place in the room.

(2) Problem-solving kit for discovering science concepts. In this kit materials are presented which will permit a pupil to discover a science concept by solving a problem that the class has not considered previously. Two small pulleys, a collapsible standard, a heavy weight, string, and a spring balance will let a child attempt to solve the problem, "How can pulleys be arranged so the least amount of force is used to lift a weight?" The child has a definite goal in mind as he utilizes the materials. He can make a hypothesis, search for a conclusion, and then check his results with the answer card.

(3) Problem-solving kit for applying science concepts. One kind of kit would allow a student to apply a concept in a functional way. A shoe-box, containing a milk carton and two plane mirrors, would enable him to employ the ideas concerning light reflection in making a simple periscope.

The second kind of kit would have the children utilize science information in a verbal manner. A large envelope could hold filing cards which suggest problems to be solved without the use of concrete materials. Information learned in prior lessons would be essential for reaching a solution. One card might ask, "Why does one's eyeglasses become wet or

"foggy" after entering a warm house on a cold day?" Another card can offer the following problem: "Suppose you were on the heavenly body called "X". If you were looking toward the earth you would just be seeing Orville Wright taking his first flight in 1903. Assuming the light reflecting from Wright continues out into space and to your position, how far is "X" from the earth?"

(4) Problem-solving kit for extending science concepts. This method of organizing materials can be used to extend the science concepts of the pupils who might be considered "above par" or "below par" in their ability or achievement. It is an effort to assist the students at the opposite extremities of conceptual development.

In one container, such as a cigar box, materials, along with directions and suggestions, can be placed which would let the "above par" student construct a simple electric motor. This is possible by using a large U magnet, a knitting needle, nail, tape, two yards of thin insulated copper wire, a dry cell, and two small filing cards.

For the "below par" pupil in the same room a kit containing a switch, dry cell, wire, and minature lamp, can be arranged. This child can work on the understandings involved in completing a simple electric circuit.

(5) Problem-solving kit for investigating science concepts. In the fifth method an effort can be made to encourage a pupil to use his imagination in exploring the phenomena of nature. The child might be asked to react to this problem: "What would our day and night cycle be like if the earth was square like a box?" A small ball to represent the earth as it is, a small box about the same size as the ball, and a flashlight would let the investigator reach possible conclusions to this question.

Many advantages can be gained by organizing materials for individual lessons as represented by these five types of kits. An outstanding feature is that active consideration can be given to the various levels of conceptual development within a classroom.

Pupils are presented with problem solving situations. A purpose can be established to act as a guide for the child. At times, when materials are located all together in the corner it creates a chaotic condition. Materials are mislaid, children did not understand the related lessons, some children forget what the materials were to be used for, or some children might have been absent. These are some factors which can lead to ineffective utilization of materials as learning devices.

The kits might be used as an excellent kind of homework. Some pupils (the girls and those pupils who work slowly) never seem to get an opportunity to examine and use the science materials. Arrangements should be made so the students can sign out the problem-solving kits as they do library books. In cases of over-crowded rooms or limited supplies, this method of organization could be used to ensure more efficient use of available materials.

While this article has been concerned mainly with the learning of science concepts or the "big ideas" through the organization of materials, it should be recognized that the other objectives of a desirable elementary science program are not being overlooked. The child is also given a chance to become a better problem solver, to develop a scientific attitude, and to recognize and appreciate the role of science in his environment.

A STUDY OF AURORAL FLUCTUATIONS

Work by the National Bureau of Standards and the University of Alaska indicates that short-period auroral fluctuations are closely related to micropulsations of the earth's magnetic field and ionospheric absorption of cosmic noise. These variations originate in the E-region of the ionosphere, and are associated with a bombardment of outer atmospheric electrons.

from TECHNICAL NEWS

Poliomyelitis Vaccine

(*Continued from page 108*)

poliomyelitis in the United States and Canada during the past year indicates that, while the available Salk vaccine has undoubtedly prevented a great deal of paralytic poliomyelitis, it is inadequate in eliminating the disease or providing full protection.[19]

Although the use of the Sabin vaccine was endorsed by the United States Government in August, 1960, it won't be on the market before September, 1961. This vaccine may supply more solid immunity to an individual and do a better job of curbing the natural spread of polio virus, but this remains to be seen. In any event, neither vaccine is likely to wipe out polio completely because it is hard to get enough people inoculated to achieve this goal.

There have been improvements on the Salk vaccine also. Many doctors now are using a four-in-one vaccine, which offers protection against whooping cough, diphtheria and lockjaw as well as polio. Besides, the Government's potency requirements will go up 50 per cent early in 1961, and it may yet be possible to make the Salk vaccine so powerful, perhaps in the next five to ten years, that one shot will provide lifetime immunity.[20]

That newspaper article on April 12, 1955, is the symbol of years of research and financial investments, but it is also the symbol of future work in poliomyelitis research.

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[19] Sabin, 868.

[20] *Pittsburgh Press*, December 1, 1960, p. 13.

(*Continued from page 103*)

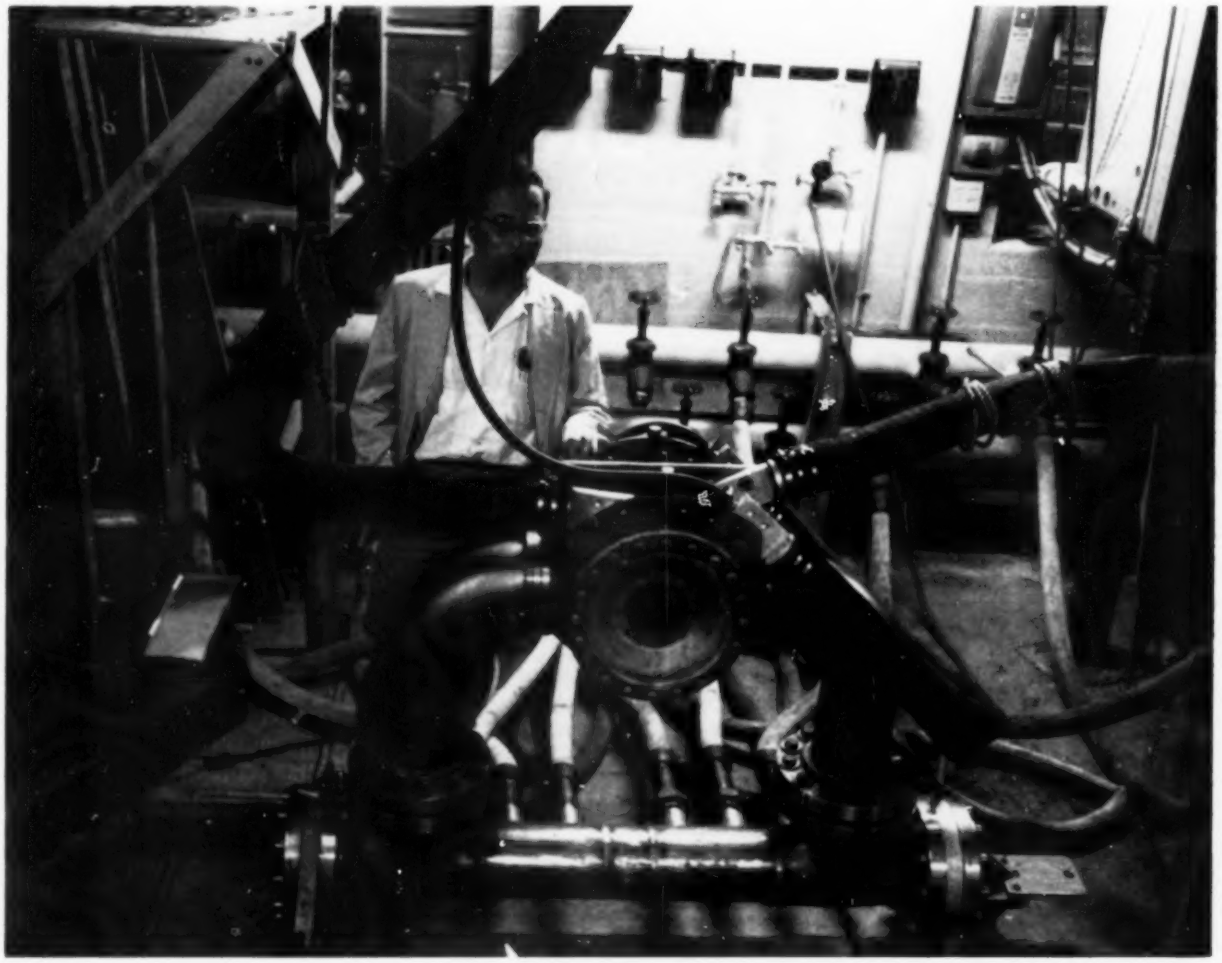
250,000 gauss in the new laboratory. The power supply for the new magnet facility will have a DC capacity of 8 megawatts continuous rating supplied by two motor-generator sets. One single motor-generator unit is capable of furnishing up to 10,000 amperes of direct current at less than 0.1 per cent ripple and is readily controlled by means of field excitation. The use of several units affords the flexibility of separate or combined series or parallel operation.

The cooling system must be closed and filled with purified and deionized water to prevent blocking of the very small flow channels in solenoids and to reduce electrolysis. Water in this closed system will circulate at the rate of about 4000 gallons per minute through a heat exchanger capable of transferring 8 megawatts of heat to the Charles River.

The proposed facility would provide a variety of solenoid magnets specifically adapted for different types of experiments. A maximum field of 250,000 gauss or possibly more will be provided in a one-inch caliber solenoid, and larger-caliber solenoids would achieve correspondingly lower fields. Some solenoids would provide fields homogeneous over a large volume, while others would sacrifice homogeneity for the sake of obtaining the maximum possible optical aperture. Still others would utilize a Helmholtz double-coil design so as to provide lateral access. The laboratory building and the motor generator sets are now under construction and the new facility is expected to be ready for operation early in 1963.

No one can say what exciting new knowledge may emerge when these extremely intense magnetic fields are put to work for research.

Fig. IV. Dr. Henry H. Kolm of the National Magnet Laboratory at M.I.T. shown with his water cooled 1 inch aperture electromagnet. This magnet produces a continuous magnetic field of 126,000 gauss which, as far as is known, is the largest continuous field ever produced. This magnet was designed while Dr. Kolm was a staff member at the M.I.T. Lincoln Laboratory.



NEW BOOKS

The Teaching of Arithmetic

By F. F. POTTER. Philosophical Library, New York 1960, 462 pages.

The Teaching of Arithmetic by Potter is a book which combines most of the good features one would find only by reading many books in the teaching of arithmetic area.

Author Potter has combined the easily understood, encouraging verbal introductions with sound mathematical illustrations. His style of presentation and depth of understanding reveals his excellent background of working with children and teachers in the elementary schools.

While the basic information in this text could be used in America as well as in England there are some sections of the book which would impose hardship. In discussing certain measures and mnoey values the units involved are typically English. This does not mean that there would not be some value in teaching these concepts as well as the ones normally used in other countries.

Mr. Potter has an excellent style in presenting advanced material. He covers each step in such a thorough manner that the following material is easily understood. This aspect of the book should be particularly appealing to those who lack sufficient mathematical background.

The last chapter provides some excellent activities which the author suggests for stimulating thought. These ideas are correlated with the various topics covered in the text and would be excellent enrichment experiences for the students.

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Studies in Paleobotany

By HENRY N. ANDREWS, JR. John Wiley and Sons, Inc., New York and London, 1961, $9.75 487 pages.

This book is designed for a one semester course, introducing the student to principles and details of paleobotany. Although it has sufficient detail for this purpose it should not become burdensome to the student. The book is carefully written in clear, concise language which results in a very readable and dignified treatment of the subject matter. The author is obviously well qualified in the field of paleobotany and does not hesitate to present his views, where appropriate, in discussions and summaries of various aspects of the field. The author used to good advantage occasional comparisons with extant plants. The organization of the text is such that it offers the possibility of a flexible treatment of the subject matter. While the book contains adequate summary tables, additional ones more extensively correlating time and flora sequences could have been included to advantage. The text is profusely illustrated, a number of the illustrations being exceptionally excellent. Included in the book is a special chapter prepared by Dr. C. J. Felix, introducing the student to the important and expanding field of palynology. This chapter should stimulate additional interest on the part of the student. The book also contains a special chapter of some of the techniques employed in the preparation of fossil plants for study and should stimulate the actual preparation, in class, of material collected from the field. The end of each chapter provides a listing of selected references pertinent to the discussions.

Studies in Paleobotany is a text worthy of consideration for an introductory course in paleobotany.

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The Universe and Dr. Einstein

By LINCOLN BARNETT. Mentor book, 60¢, New America Library of World Literature, New York, New York, 128 pages.

This paperback is an attempt to present an abstract scientific subject in a popular manner—a difficult chore at best. The basic purpose is to clarify some of the popular terms and laws that govern the physical reality of the world. In addition, however, it is an attempt to reveal that Einstein's relativity actually comprises a major philosophical system which augments and illumines the reflections of the great epistomologists—Locke, Berkeley, and Hume.

While bringing knowledge in this area up-to-date, the book offers an opportunity for more contemplative and reflective thinking. A sense of the tremendous "beyond" is realized although the achievements of the past and present are not minimized.

Einstein's basic contributions are presented; his extension of Plank's Quantum Theory to all forms of radiant energy and his attempt to produce the yet incomplete unified field theory, which would set forth in one series of mutually consistent equations the physical laws governing two of the fundamental forces of the universe, gravitation and electromagnetism, both in the macrocosmos and the microcosmos. Such topics as relativity of time, distance, and mass are all explained so that the reader can grasp the "essence" of each. Examples to clarify these important concepts which describe the mechanics of the physical universe are especially effective.

Dr. Einstein's single dedicated purpose in life is everywhere apparent to the reader. His contribution in extension, application, and clarification to the many classical contributions of others such as Michelson, Morley, Newton, and Plank are described. Everywhere is Einstein's

(Continued on next page)

New Books

(Continued from previous page)

suggestion for man not to harness himself by thinking only as man but to go to abstraction beyond to overcome heretofore limitations. His suggestion that the world would appear far different to man if his eyes were sensitive to X-ray rather than the spectrum of visible light is a rather interesting example.

Dr. Einstein's contribution to the concept of the Universe is found in clear and concise terms, with appropriate simple examples, leads one to reexamine and speculate on its creations.

One cannot but be impressed by Albert Einstein's ability to comprehend the incomprehensible, to apply the inapplicable, to generalize the ungeneralizable, to explain the unexplainable, and to question the unquestionable.

A rather interesting thread of anti-atheism is woven throughout the book to tear at the general accepted belief that Einstein was atheistic.

The book is excellent and, for such a complex topic and such a great area to cover and integrate, does an excellent job to orient the non-mathematician in an appreciation of the great contributions of this one man, Albert Einstein. The book offers newer and broader meanings to Einstein's contributions in an easily understood non-mathematical treatment. Although one must study the book carefully, the basic condensation is a great aid to the non-scientist or a scientist who may lack the depth in the specific fields of science.

M. A. S.

Physical Geography

Second Edition by Arthur N. Strahler. John Wiley & Sons, Inc., New York, 1960, $7.50, 534 pages.

This second edition of Strahler's *Physical Geography* retains the same fine qualities found in the first edition. The book has been extensively revised and rewritten to incorporate not only recent advances in the field but also the valuable suggestions made by leading authorities in response to a widely circulated questionnaire.

This is an excellent college text for the teaching of Geography containing valuable exercises at the end of each chapter with excellent maps, data tables, and graphs required for their solution.

Juanita P. Forge
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Cell & Psyche

By Edmond W. Sinnott. The Biology of Purpose, Harper Torchbook, The Science Library, 95¢, New York, 119 pages.

This paperback, one of the many Harper Brothers publishes, is an outgrowth of the McNair lectures at the

(Continued next page)

New Books

(*Continued from previous page*)

University of North Carolina combining the original with subsequent papers on the same general theme.

Although the work is one of speculation it has enough scientific basis to be intriguing and believable. The Dean of the Graduate School at Yale University presents a most provocative argument to tie the mind and the body into meaningful unity. This relationship between philosophy and biology is the single driving force within the book.

The character of the constituents of a living thing is not the essence but the relationships among them is that which is most important. The relationships are discussed with the ultimate conclusion that "life is the maintenance of such a constant set of conditions, and death is the inevitable result of their dislocation."

Implications for philosophy are presented as a summary utilizing comparisons between the body and the mind citing examples such as: The effects of drugs upon memory, the clear relation between specific regions of the brain and the psychological state, and the speculation that electricity may ultimately be explained better through biology.

Freedom of will, the conscience, and the soul are dealt with in biological terms ultimately concluding that there exists "a continuous progression from the biological goals operative in the development and behavior of a living organism is the psychological facts of desire and purpose".

The broad goal of the "relativity of man" is hinted at with $e = mc^2$ being only a minor point in this important integrating process.

The book is most interesting and offers food for thought for the reflective reader in his eternal attempt to seek unity in all aspects of life. With a little biological background the reader should have no difficulty following the many arguments presented. Speculation and thought is everywhere in the book with ample substantiation to make one "think".

The primary thesis that the author presents is excellent and the work should be read by anyone interested in learning who continually contemplates the many "bridges" that must be crossed.

M. A. S.

Writing a Technical Paper

By Donald H. Wenzel, Howard Munford Jones and Lyle G. Boyd, McGraw-Hill Book Company, Inc. 330 West 42nd Street, New York 36, New York, $3.25, 132 pages.

This book seems to meet an important and growing need of the scientist who lacks the academic background for effective writing and the necessary time to alter the situation. Technical writing for publication is becoming an increasingly important part of our scientific society. Although not unique, the book is written in a simple and straight-forward manner with rather complete and logical

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New Books

(Continued from previous page)

coverage. The name of the book is appealing with the physical size sure to be inviting to a segment of our technical population who appreciates any time saving devices. The book covers the necessary steps in technical writing from the inception of the paper through the revision and ultimately to the physical manuscript of the completed product. Numerous examples to clarify various rules of grammar and style are to be found throughout the book.

The book has a fine framework within which to work, but it seems to lack that which many scientists look for: a summary or set of rules to summarize each phase of the technical writing. Because each chapter is brief in and of itself, a summary may be superfluous. This apparent search for summarizing rules for technical writing may be merely an individual bias. In general, the book is most certainly needed and does serve as a framework within which quality technical writing can become a reality.

M. A. S.

The Impact of the New Physics

By FRANK HINMAN. Philosophical Library Inc., New York, New York.

The Impact of the New Physics by Dr. Frank Hinman is an easily read and brief philosophical summary of new facts of science and how they have expanded our ideas of the origin of life, the nature of the mind, the personality and the destiny of man. Physics in the past sixty years has initiated and dominated the explanation of all natural events. It has promoted the "space age." Is the universe expanding, what is the fate of the earth, and is there intelligent life elsewhere are some of the questions raised. The next section of the book concerns the organic side of matter and traces the evolution of life on earth from the simplest molecule which has the property of reproduction to man the most complex organism and his nervous system. Finally, the author discusses the social evolution of man, the sciences of his mind, personality and spirit. All of these discoveries have had an effect on man's welfare and happiness. They are changing the attitudes of people in a moral and spiritual way. Perhaps the newest and most worthwhile task of science today is to find a way to contribute to the sociological evolution and the spiritual happiness of man. At the conclusion of each chapter there is voluminous collateral reading for the interested reader.

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Giving Mathematics Meaning

(Continued from page 100)

Addition on this clock is defined by movement of the hand of the clock in a clockwise direction. The following table shows us the entire addition setup.

+	0	1	2
0	0	1	2
1	1	2	0
2	2	0	1

We have many funny addition facts such as $1 + 2 = 0$. This table is excellent though to show the meaning of the closure, commutative, and associative properties, and the table helps the students to find identity elements and inverses. We see that this table shows us the identity element 0, easily.

$$0 + 0 = 0$$
$$0 + 1 = 1$$
$$0 + 2 = 2$$

Inverses are numbers which add up to the identity elements such as 0 and 0, 1 and 2.

My assignment was, "Make up a system of your own that has all of the properties." The results were astounding. One little girl in roster 12 made a system of horses. She enjoys drawing horses (on everything). Since the roster 1 and 2 posters were hanging in the classroom I explained a little bit about them to rosters 11 and 12. Donna asked me if she could please do a poster.

If children can be stimulated to think for themselves and to do excellent creative work on their own in this fashion, I think that we can stop trying to justify the use of modern mathematics. Just look at the happy faces!

Editor's Note

The Maryland Plan (or Study) referred to in this article is a method of striving for more meaning in the development of various concepts in mathematics. These concepts, heretofore, had been taught in a mechanical manner, using drill as the primary means of reinforcement. Critics of this older and more traditional plan have stated that the students attach no meaning either to the concept or to the procedure. For example, in division of fraction, one was taught to "invert and multiply."

i.e. $1/3 \div 1/2 = 1/3 \times 2/1 = 2/3$ = answer

The Maryland Plan, basically, is to write the original problem as a fraction rather than in linear form and convert the denominator of this latter fraction to unity by multiplying both th denominator and the numerator by the same number.

i. e. $1/3 \div 1/2$ rewritten as $\dfrac{1/3}{1/2}$

Now, multiplying both numerator and denominator by the same number, $2/1$, (the reciprocal of the denominator) the denominator becomes one. This procedure does not change the value of the fraction, and is perfectly acceptable, meaningful, and transferable to later mathematical work.

$$\frac{1/3 \times 2/1}{1/2 \times 2/1} = \frac{1/3 \times 2/1}{1} = 1/3 \times 2/1 = 2/3 = \text{answer}$$

As the reader can note, the procedure is essentially "inverting and multiplying," but a dimension of meaning has been added to the previously mechanical approach.

Although the example is necessarily simple, the basic idea is presented. Further details on this plan can be obtained by writing to the University of Maryland, College Park, Maryland.

The importance of Research

(*Continued from page 116*)

someone to wash the glassware so that you'll have more time to think." The next time the president came in, he found the professor reading. Again, he said, "Doctor, your time is too valuable for this. I'll hire someone to do all the reading and make abstracts for you." In scene three, the professor is sleeping on the beach. The point is that while the professor was showered with all these advantages, his enthusiasm was also killed.

Granted there are obstacles and difficulties and granted it would be nice to have the advantages; nevertheless, the primary requisite for research is the proper attitude of mind, the desire to do research, the curiosity to understand. The other obstacles are really minor problems. If one wants to do research, he can learn to master the techniques necessary to carry out a successful piece of research. He can learn how to get support. Directions for doing this can be obtained from the Foundations themselves and advice can be readily obtained from those who were successful in getting support for themselves. One can even learn how to get research ideas. There have been several plans developed within the organization of the Pennsylvania Catholic Round Table of Science where those who are doing research would help others get started. One can learn how to adapt the project to his limited time. The one difficulty remains—the research curiosity. If the desire to do research is great enough, all the other obstacles can be overcome.

BIOLOGISTS are scientists who study the structure and life cycle of all living things—as diverse a field as life itself!

INDEX TO VOLUME XXIV—1961

Articles are listed under the author's name. Book reviews are listed under the name of the author of the book. (R) indicates a book review. The name of the reviewer follows in parentheses.